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# PATENT SPECIFICATION

121  
704.002

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## COMPLETE SPECIFICATION

### Improvements in Hot-Gas Reciprocating Engines

We, N. V. PHILIPS' GLOEILAMPEN-FABRIEKEN, a limited liability Company, organized and established under the laws of the Kingdom of The Netherlands, having our seat and Office at Emmasingel, 29, Eindhoven, Holland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to hot-gas reciprocating engines having heaters comprising bent tubes.

According to the invention, a hot-gas reciprocating engine having a heater comprising bent tubes, one limb of each being connected to the hot space and the other limb to the regenerator which surrounds the working cylinder of the engine, is characterized in that all the tubes are bent in such manner that beyond the cylinder head and extending on that side of the cylinder head remote from the cylinder and over a major portion of their length they are situated equidistantly, or substantially equidistantly, from the cylinder axis.

It has now been found that, when a heater comprises bent tubes surrounding a space for the combustion gases, for example, a combustion space, and of each tube one limb provides a connection to the hot space and the other limb provides a connection to the regenerator space of the engine, the limbs along which the combustion gases first flow will, as a rule, be heated to a greater degree. In an engine according to the invention, since the tubes are bent in such manner that, throughout a portion of their length, they are equally spaced from each other around the periphery of the cylinder, the combustion gases can pass along the tubes in a more uniform manner, so that the highest temperature of the tubes will be lower than in cases where the combustion

gases pass along non-uniformly spaced tubes.

For structural reasons, the distance between the bend and the point of connection to the regenerator space may exceed the distance between the bend and the point of connection to the hot space. This affords the advantage that an increased amount of thermal energy may be extracted from the combustion gases, thus considerably increasing the amount of heat transmitted to the tubes.

The portions of the longer limbs projecting beyond the shorter limbs may be provided with means, such as fins, positioned at right angles to the longitudinal directions of said portions in such manner that the combustion gases pass between said portions in parallel channels, thereby increasing the thermal transmission therethrough. It may thus be ensured that the combustion gases are brought into more intimate contact with the tubes, with the result that the thermal transmission is further improved.

The invention will now be described more fully by reference to the accompanying diagrammatic drawing showing, by way of example, one embodiment thereof, in which:—

Figure 1 shows a hot-gas reciprocating engine in part vertical section taken through the vertical centre line of the cylinder, and

Figure 2 is a sectional view taken on the line II—II of Figure 1.

Referring now to the embodiment shown in the drawing, a hot-gas reciprocating engine comprises a displacer piston 2 and a working piston 3 adapted to reciprocate with a constant phase difference in a cylinder 1. The displacer piston 2 and the working piston 3 are associated by means of connecting rods to a crank-shaft (not shown). The working medium flows to the working space 4, through a group of tubes 5, disposed co-

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axially with the combustion space 10 and the cylinder axis, a regenerator 6, a cooler 7 and a cold space 8. The inner limbs 5a of the tubes 5 are bent in such manner that the spacing for the combustion gases between any pair of adjacent tubes 5a and 5b is the same. The arrangement of the limbs is shown in Figure 2, which is a cross-sectional view taken along the line II—II of Figure 1. The heater is furthermore provided with a burner 9. The combustion gases flow from the centrally positioned combustion space 10 along the series of tubes, thus heating the limbs 5a, 5b, simultaneously and equally. Subsequently, the combustion gases pass along the portions 5c of the limbs 5b projecting beyond the shorter limbs 5a. In order to improve the thermal transmission to the portions 5c, the portions 5c are provided with projections, in this case, fins, 11, positioned substantially at right angles to the longitudinal direction of the limbs, so that the combustion gases flow along the portions 5c in a number of parallel channels. The combustion gases finally leave the heater at 12.

It will be evident that the fins 11 may, for example, extend parallel to the longitudinal direction of the portions 5c instead of at right angles thereto.

In the embodiment described above, the tubes are arranged concentrically about the combustion space and the regenerator surrounds the working cylinder of the engine, combustion gases being provided centrally and leaving the heater at its periphery. It is obvious, however, that the construction according to the invention is also applicable to an engine in which combustion gases are supplied at the periphery of the group of tubes and carried away centrally. Furthermore, it is not required that, as is the case in Figures 1 and 2, the limbs of the tubes are bent through a portion of their length in such manner that on a cross-section through this portion the cross-sections of the tubes are located on the same circle. The limbs may be bent at this portion in such manner, in section at right angles to the centre line of the cylinder, that the tubes are staggered with respect to each other and form a zig-zag pattern, so that

in effect there is a slight difference in the distances of the tubes from the cylinder axis. To ensure satisfactory operation of the heater, it is necessary, however, that the passages for the combustion gases between all of the limbs are equal.

What we claim is:—

1. A hot-gas reciprocating engine having a heater comprising bent tubes one limb of each tube being connected to the hot space and the other limb to the regenerator which surrounds the working cylinder of the engine, characterized in that all the tubes are bent in such manner that beyond the cylinder head and extending on that side of the cylinder head remote from the cylinder and over a major portion of their length they are situated equidistantly, or substantially equidistantly, from the cylinder axis.

2. A hot-gas reciprocating engine as claimed in Claim 1, characterized in that for each tube, the distance between the bend and the point of connection to the regenerator space exceeds the distance between the bend and the point of connection to the hot space.

3. A hot-gas reciprocating engine as claimed in Claim 2, characterized in that the portions of the longer limbs projecting beyond the shorter limbs are provided with means for increasing the thermal transmission thereto.

4. A hot-gas reciprocating engine as claimed in Claim 3, characterized in that the means comprise fins.

5. A hot-gas reciprocating engine as claimed in Claim 3 or 4, characterized in that the means or fins are positioned at right angles to the longitudinal directions of said portions in such manner that the combustion gases flow along said portions in parallel channels.

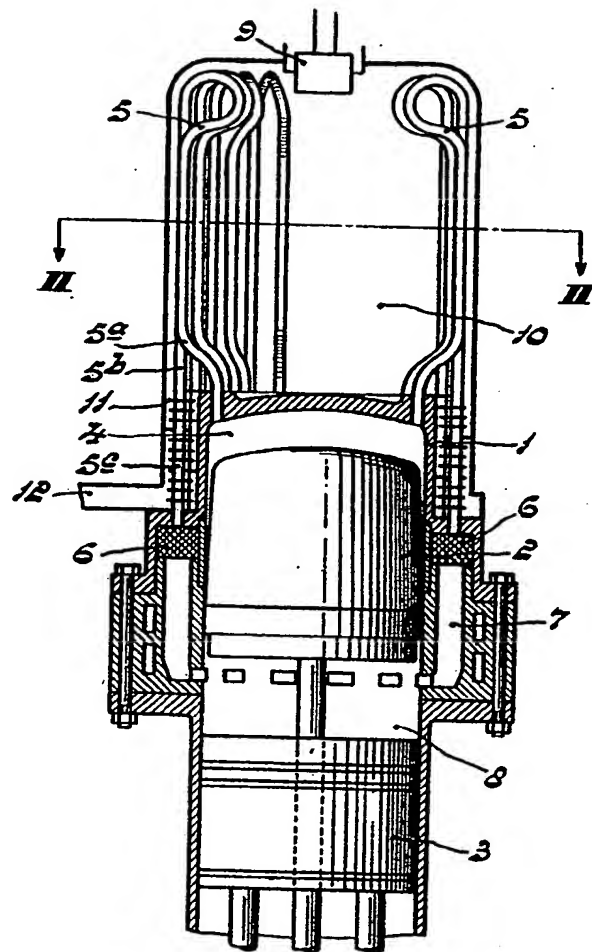
6. A hot-gas reciprocating engine, substantially as herein described with reference to the accompanying drawing.

Dated this 7th day of February, 1951.

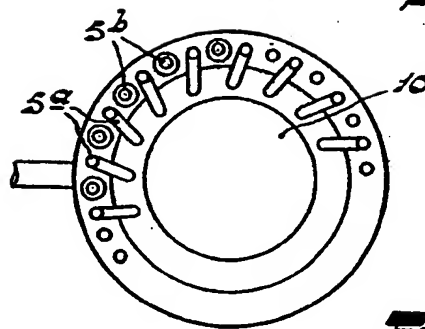
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704,002 COMPLETE SPECIFICATION  
1 SHEET

This drawing is a reproduction of  
the Original on a reduced scale.



**Fig. 1**



**Fig. 2**

